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(Equations Linéaires) introduce an arbitrary parameter p and write $\|z\| \equiv \sqrt[p]{\sum |z_{(n)}^p|}$ as an instance.

¹ H. B. Fine, these *Proceedings*, 2, 546 (1916).

² J. Kürschak, *J. Math., Berlin*, 142, 211-253 (1913).

THE COBALTAMMINES

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The metallic elements whose properties of aggregation are such that they have low atomic volumes, or high 'cohesion,' form a series of complex ammonia compounds whose stability seems to increase with the cohesion, or decrease with the atomic volume of the metallic aggregate. These complex ammonia compounds, or ammines are of peculiar interest because, like the hydrates, their structure has not yet been explained in a satisfactory way from the standpoint of ordinary valence theories. Werner, however, has developed a special theory of valence which seems to fit very well the chemical behavior of these particular compounds, whether or not it is in agreement with the general behavior of other chemical substances.

Now perhaps the most important point to be established with respect to a series of salts such as these ammines, is the type of each salt with reference to its ionization in solution. When we turn to the work of Werner and of other investigators in this field, it is found that no work has been done which determines directly the type for these salts, although it might be considered that their molecular conductance as determined by Werner, together with their chemical action, makes it seem probable that they belong to the types according to which he has classified them.

The freezing-point method should give the most easy and certain method for the determination of the type of such salts as these, but it is just here that not only the work of other investigators, but even that of Werner¹ himself, does not agree with his theory. Since in this laboratory there is a double combination potentiometer system specially designed for us by Dr. W. P. White, to give with a fifty-couple copper-constantan thermocouple a reading to one twenty-thousandth of a degree, it seemed advisable to make for the first time a series of accurate freezing-point measurements upon the special series of cobaltammines which was most used by Werner in his work. The analyses were made by a Haber-Zeiss water interferometer, loaned to us by the Geophysical

Laboratory through the kindness of Drs. John Johnston and L. H. Adams. The only troublesome feature of the analyses was that caused by the color of these salts; and the difficulties encountered were such that it seems advisable in future work upon these salts to determine the concentration of the solutions by the conductivity method, since that method would render unnecessary the frequent gravimetric analyses which had to be resorted to, in order to make certain that the proper interferometric bands were being read.

In order to give a comparison of the results with those obtained formerly, the following table is inserted, which gives a few of our values of the equivalent freezing-point-lowerings ($\Delta t/N$) at rounded concentrations, upon a number of these salts, including the interesting isomeric salts dinitrotetrammine cobalt chloride (croceo) and dinitrotetrammine cobalt nitrate (flavo), which are shown by the freezing-point results to be of the di-ionic type. The values obtained by Werner and Herty and by Peterson are given within parentheses. The table also contains the corresponding values of the van't Hoff coefficient or mol-number i , and those of the percentage ionization (including those derived from the conductivity-ratio).

While the results of Werner and Herty were very severely criticised by Peterson,² it will be seen that they are of the right order of magnitude, while Peterson's own results are about 100% too large, a divergence difficult to explain. The table shows that, while for the croceo salt the values of Werner and Herty are only about 8% too low, for the hexammine they obtained values which were so high (see figure) as to indicate that they belong to other types of salts than is the case; but on the whole the deviations of their results are explained by the fact that they used a Beckmann thermometer, and by the fact that most of the cobaltamines are not very soluble, so that the measurements have to be made in very dilute solutions, which makes the percentage accuracy much less than it would be at such concentrations as are commonly used.

The salts investigated are given in the following list, together with the number of ions which we have found that each salt produces.

	Ions
Hexammine (luteo) cobalt chloride.....	4
Nitropentammine (xantho) cobalt chloride.....	3
Chloropentammine (purpureo) cobalt chloride.....	3
Dinitrotetrammine (flavo) cobalt chloride.....	2
Dinitrotetrammine (croceo) cobalt chloride.....	2
Trinitrotriammine cobalt	0
Potassium tetranitrodiammine cobaltate.....	2
Ammonium tetranitrodiammine cobaltate.....	2
Sodium cobaltic nitrate.....	4

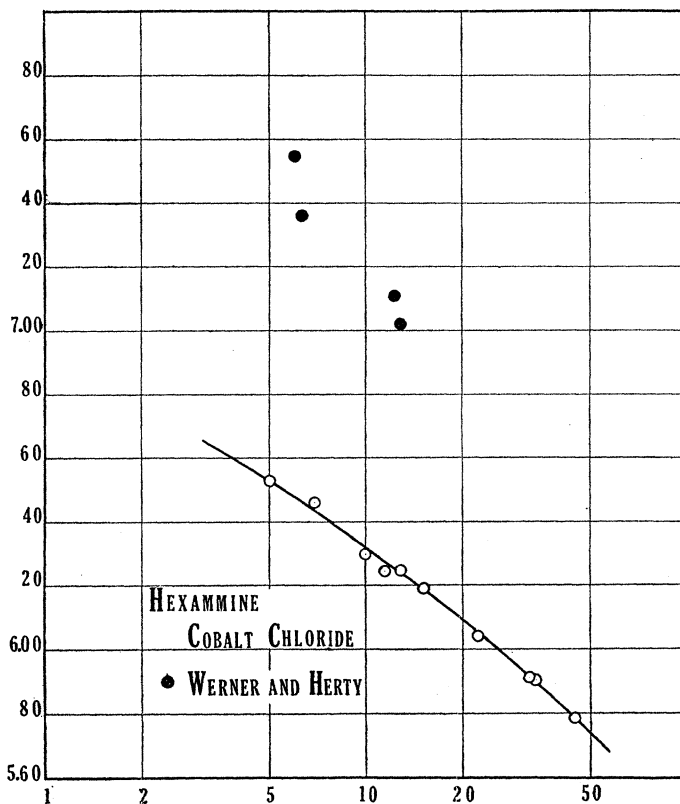
TABLE I

Concentration in milli- equivalents	Equiv. fr. pt. lowering $\Delta t/N$	Mol-number i for the cobaltammine	for potas- sium iodate	Percentage Fr.-Pt. Lower	Ionization from Conductivity
<i>Flavo Cobalt Nitrate</i>					
2	3.65	1.964	1.967	96.4	96.6
5	3.595	1.935	1.958	93.5	93.8
(5)	(7.00)*				
10	3.531	1.900	1.937	90.0	91.2
(10)	(6.60)*				
20	3.446	1.855	1.908	85.5	
(20)	(6.15)*				
<i>Croceo Cobalt Chloride</i>					
2	3.66	1.97	1.967	97.0	95.4
(4.35)	(3.45)†				
(4.72)	(3.60)†				
5	3.622	1.949	1.958	94.9	93.2
10	3.590	1.932	1.937	93.2	90.7
20	3.556	1.914	1.908	91.4	
<i>Hexammine Cobalt Chloride</i>					
5	6.53	3.51		83.7	
(6)†	(7.54)	(4.055)			
	(7.36)	(3.95)			
10	6.32	3.40		80.0	
(12)†	(7.11)				
	(7.02)				
20	6.09	3.22		74.0	
50	5.74	3.09		69.0	
<i>Chloro-pentammine Cobalt Chloride</i>					
5	5.35	2.88		94.0	
10	5.18	2.785		89.0	
20	4.95	2.66		83.0	
<i>Nitro-pentammine Cobalt Chloride</i>					
5	5.26	2.83		91.5	
10	5.13	2.76		88.0	
20	4.935	2.655		82.7	
<i>Potassium tetra-nitro-diammine</i>					
2	3.675	1.975		97.5	
5	3.65	1.95		95.	
10	3.62	1.945		94.5	
20	3.57	1.92		92.	
50	3.505	1.885		88.5	
<i>Ammonium tetra-nitro-diammine</i>					
2	3.66	1.95		95.	
5	3.62	1.945		94.5	
10	3.565	1.92		92	
20	3.49	1.88		88.	

* Peterson. † Werner and Herty.

These results are in accord with Werner's theory in so far as the number of ions is concerned.

When the apparent ionization values for these salts obtained by the conductivity and freezing-point methods are compared, it is found that they are closely similar, except in the case of the tetraionic salt, when the result calculated from the freezing-point is much the higher. The deviation is in such a direction as could be explained by the theory of Harkins¹ that all salts of this and other higher types give a considerable



percentage of intermediate ions in solutions of about 0.1 normal concentration. It is of course realized that the apparent ionizations obtained by the two methods are in no cases directly comparable, since we do not know the variation in the activity of the different components.

While many of the cobaltamines are unstable and hydrolyze rapidly at higher temperatures, at zero degrees no trouble was experienced, except with dinitrotetrammine cobalt chloride when it was exposed to a bright light, and with sodium cobaltic nitrite.

The writers wish to express their indebtedness to the National Academy of Sciences for a grant of two hundred dollars from the Wolcott Gibbs Fund, which has been used to purchase the apparatus for this work. The complete paper will be published in the *Journal of the American Chemical Society*.

¹ Werner and Herty, *Zs. physik. Chem.*, **38**, 331 (1901).

² Petersen, *Zs. physik. Chem.*, **22**, 410 (1897); **39**, 249 (1902).

³ Harkins, *J. Amer. Chem. Soc.*, **33**, 1807-73 (1911).

NATIONAL RESEARCH COUNCIL

REPORT OF THE FIRST MEETING OF THE COUNCIL

The first meeting of the Research Council was held in New York City on September 20, 1916.

Dr. M. I. Pupin, as Temporary Chairman, called the meeting to order at 3.10 p.m., and directed a roll-call of the members of the Council. There were present the following members: Messrs. Carty, Dunn, Goss, Hale, Herschel, Holmes, Keen, Manning, Marvin, Millikan, Noyes, Pickering, Pupin, Rand, Skinner, Squier, Stratton, Swasey and Vaughan.

The Temporary Chairman then called for nominations for Permanent Chairman. Dr. George E. Hale was nominated and unanimously elected. Dr. Hale then took the Chair and presided for the remainder of the meeting. Dr. Charles D. Walcott was elected First Vice-Chairman, and Mr. Gano Dunn, Second Vice-Chairman.

Dr. Hale, as Chairman of the Organizing Committee of the Council, announced an agreement between the National Academy of Sciences and the Engineering Foundation by which the Engineering Foundation has placed its funds at the disposal of the Council for a period of one year and has given the services of its Secretary, Dr. Cary T. Hutchinson, to the National Research Council, to serve as its Secretary. Dr. Hale announced that in accordance with this agreement the National Academy of Sciences has appointed Dr. Hutchinson Secretary of the National Research Council. Dr. Hutchinson was present and acted as Secretary to the meeting.

The Chairman then gave an extended account of the work done by the Organizing Committee during the summer months, dwelling particularly upon his trip to England and France, and upon the results that have been reached there by similar organizations of the men of science.

At the conclusion of the Chairman's remarks the organization of the Council was discussed; and the motion was made that an Executive Committee to consist of a chairman and nine members be appointed by the Chair, with the Chairman of the Council and President of the Academy as additional mem-